

Effects of Plant Population, Row Spacing, and Relative Maturity on Dryland Corn in the Northern Plains.

I. Corn Forage and Grain Yield¹

J. Alessi and J. F. Power²

ABSTRACT

Narrow rows or equidistant planting of corn (*Zea mays* L.) has been beneficial in the Corn Belt. The concepts were evaluated at Mandan, N. D., to determine their influence under dryland conditions and in combinations with early-maturing varieties which partially evade late season drought. The 68 and 85-day relative maturity hybrids were grown at plant populations of 20,000; 30,000; 40,000; 60,000 and 74,000 plants/ha in 50 and 100-cm spaced rows for 3 years. In 1968, a "wet" year, row spacing and maturity class significantly affected dry matter production, but only population influenced grain yield. Plant population and maturity class significantly affected grain yield in 1969 and 1970, but only population influenced dry matter in 1969. Interactions were not significant. Later-maturing corn averaged 12% greater forage yield, but early-maturing corn produced 19% more grain. Average grain yields increased from 2,600 to 3,070; 3,090; 2,960; and 2,680 kg/ha with progressive increases in population. Grain yield for 50 and 100-cm rows averaged 2,890 and 2,870 kg/ha, respectively. Number of barren stalks increased and ear weight decreased with increased population. Optimum plant population for grain and forage ranged from 30,000 to 40,000 plants/ha.

Additional index words: Planting rate, Early season corn, Plant spacing, Semiarid corn grain production.

SEVERAL studies (2, 7, 8, 13, 14) have shown that decreasing row width from the conventional spacing (90 to 108 cm) to narrower spacing (generally 50 to 75 cm) may increase corn (*Zea mays* L.) production materially. Theoretically, with adequate fertility and population, the next growth-limiting factors encountered would be light penetration, carbon dioxide exchange, and other factors related to leaf area and photosynthetic rate (4, 9, 11). Findings by Shubeck and Young (12) that equidistant planting improved grain yields support this theory.

In the studies referred to above, water supply was generally sufficient to meet crop needs. However, under dryland conditions in semiarid regions, normally severe water stress may develop by early or late sum-

mer on corn or other late season crops (1, 6, 15). Consequently, the theory that narrow rows enhance productivity by increasing leaf exposure to sunlight and CO₂ may not apply in dryland regions.

Short-stalked varieties earlier than a 85-day relative maturity corn are commercially available. These hybrids mature in August, so they may escape some of the adverse effects commonly associated with late summer drought. If narrow rows were to be beneficial under dryland, one would expect that use of earlier-maturing hybrids would increase this benefit by reducing the likelihood of severe water stress occurring before maturity. Dwarf sorghums (*Sorghum bicolor* (L.) Moench.) are also commonly used in dryland regions to reduce evaporation losses from leaf surfaces during vegetative stages, leaving more water available for grain development (6, 10). Atkins and Martinez (3) concluded that short sorghum varieties could withstand higher plant populations, probably partly because of reduced rate of water loss.

Plant population, in addition to plant height, maturity class, and row spacing, affects the geometry of plant spacing and leaf distribution. All these factors may affect light and CO₂ penetration in the canopy, as well as water use rate. Consequently, the experiment reported here was conducted to determine the effects of plant population, maturity class, and row spacing on dry matter production and grain yield of corn growing under dryland conditions.

MATERIALS AND METHODS

A field experiment was established at Mandan, N. D. in 1968 to determine the effects of plant population, row spacing, and variety on 1) the progressive dry weight of various parts of the corn plant, 2) soil water use in relation to corn production, and 3) yields of corn forage and grain. The experiments were conducted in 1968 through 1970 on Temvik silt loam (Typic Haploboroll), a Chestnut soil formed from thin loess overlying glacial till. The surface 15 cm of soil contained 0.161% N and 8.5 ppm NaHCO₃-soluble P, and had a saturated paste pH of 6.6. The surface 120 cm of soil contained about 320 mm (12.5 inches) of water at field capacity (1/3 bar) and 160 mm (6.2 inches) at the 15-bar tension.

Experimental treatments consisted of a complete factorial arrangement of 1) corn hybrids (Trojan TX68 and Pioneer

¹Contribution from North Central Region, Agricultural Research Service, USDA. Received Sept. 10, 1973.

²Soil Scientists, Northern Great Plains Research Center, USDA, Mandan, ND 58554.

3872² with relative maturity (RM) of 68 and 85 days, respectively, from seeding to silking; 2) row spacings—50 and 100 cm; and 3) plant populations—20,000; 30,000; 40,000; 60,000; and 74,000 plants/ha. Treatments were completely randomized in each replication, with plot dimensions of 8.2 × 9.1 m. All plots received a surface broadcast application of 67 kg N and 30 kg P/ha in 1968 and 112 kg N and 50 kg P/ha in 1969 and 1970. In addition, 112 kg K/ha as KCl and 11 kg Zn/ha as ZnSO₄ were applied in 1969. Higher rates of N and P plus K and Zn fertilizer were applied in 1969 to avoid the possibility that lack of these elements might limit growth at the high population.

The corn was overplanted about 30 to 50% in late May and thinned to the desired population when plants were about 5 cm high. During thinning, plants were spaced to give the effect of a diamond pattern by offset plant spacing in alternate rows. The 40,000 plants/ha in the 50-cm row were spaced equidistantly in both directions. Corn was planted on the same plots each year, and above-ground material was removed after harvest each fall. Broadleaf weeds and grasses were controlled by preemergence herbicide plus cultivation.

Harvest dates were October 3, 1968; September 22, 1969; and September 17, 1970. A minimum spacing as a 100-cm border was established between harvested areas. Forage samples (12.5 m²) were cut at ground level when the corn leaves were dry due to drought or maturity following the first killing frost. Harvested corn was weighed and shocked in the field. Ears were allowed to air-dry in the shock for several weeks and then weighed for yield determination. Forage and grain yield were calculated and reported on an oven-dry basis (70°C). Yield data were statistically analyzed with results expressed at the 1 or 5% probability level. Data relative to the progressive dry-weight changes of plant parts, and soil water relationships to corn yield will be reported in separate papers.

Precipitation records were obtained at the plot site each year. Air temperature and evaporation (open pan) were recorded at the Research Center, 3 miles from the plot site.

RESULTS AND DISCUSSION

Monthly mean temperature, precipitation, and evaporation (open pan) for June, July, and August are presented in Fig. 1. In 1970, precipitation followed the normal pattern of decline as the season progressed, whereas monthly precipitation was above normal for

² Trade name is included for the benefit of the reader and does not imply any endorsement or preferential treatment of the product listed by the USDA.

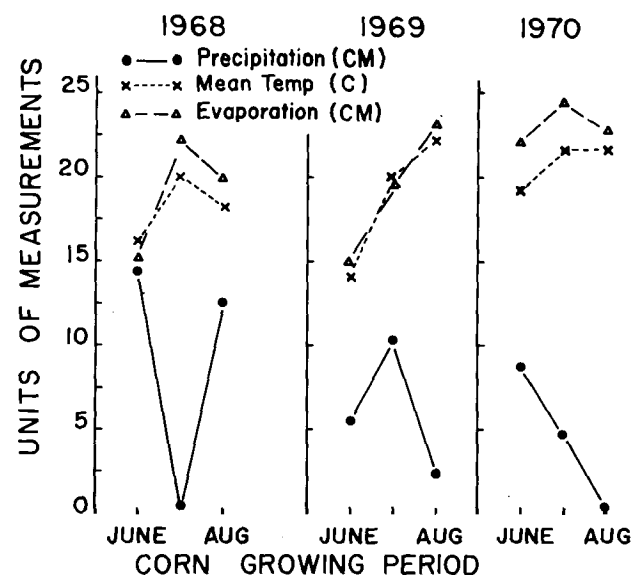


Fig. 1. Meteorological factors in 1968, 1969, and 1970 growing seasons at Mandan N. D.

Table 1. Statistical significance of effects of corn variety, population, and row spacing on forage and grain yields.

Source of variance	Forage			Shelled Corn		
	1968	1969	1970	1968	1969	1970
Row Spacing (R)	**	ns†	ns	ns	ns	ns
Population (P)	**	*	ns	**	**	*
Variety (V)	**	ns	ns	ns	**	**
R × P	ns	ns	ns	ns	ns	ns
R × V	ns	ns	ns	ns	ns	ns
P × V	ns	ns	ns	ns	ns	ns
R × P × V	ns	ns	ns	ns	ns	ns

*, ** Significant at the 5 and 1% level, respectively.

† ns = not significant.

June and August in 1968 and below normal for June and August in 1969. Temperature and evaporation were considerably above that for 1968 only in August 1969 and in all of 1970. Seasonal precipitation was 27, 18, and 14 cm in 1968, 1969, and 1970, respectively, compared to a normal of 19 cm.

Seasonal climatic variation affected plant response. In 1968, corn plants remained green throughout the growing season, though precipitation was low in July. In 1969, drought symptoms became evident at about the milk stage of development. In 1970, drought stress developed 1 to 2 weeks earlier than in 1969. All treatments were under stress before milk stage, with 85 RM corn showing symptoms much earlier than 65 RM corn. Plant stress was enhanced by increasing plant competition with higher planting rates. Row spacings had little effect upon the development of drought stress symptoms. All plant leaves of all treatments exhibited firing when harvested in both 1969 and 1970.

Statistical significance was determined for the effects of population, row spacing, maturity class, and all interactions on forage and grain yield (Table 1). Population affected grain yield in all 3 years and dry matter yields in 1968 and 1969. Row spacing affected total dry matter only in 1968 and grain yield in no year. Maturity class significantly influenced grain yield in 1969 and 1970 and dry matter in 1968. Effects of these variables were independent of each other.

Dry matter and grain data for the 3 years are presented in Fig. 2 and 3, respectively. In 1968, a year of favorable water supply, dry matter and grain yields usually were maximum at the 60,000 plant population. Forage production was greater with narrow row spacing, suggesting that the water shortage was not severe enough to completely overcome row width effects in 1968.

The toll of drought on corn yields was illustrated in 1969 and 1970. In those years of normal or below normal precipitation, dry matter yield was maximum, ranging from 7,100 to 8,120 kg/ha, at 30,000 to 40,000 plants/ha. Grain yields were nearly maximum, ranging from 2,010 to 3,290 kg/ha, at 30,000 plants/ha. Under water stress, plants tended to be larger at the low population, thereby compensating in weight for the greater number of smaller plants at the high planting rate.

Dry matter production by the 85 RM corn hybrid averaged 12% greater than that of the shorter, early-maturing variety. In contrast, the 68 RM corn hybrid produced 19% more grain. With varieties combined, 3-year average dry matter yields were 6,670; 7,660; 8,060; 8,460; and 8,270 kg/ha, in the order of increasing population, and average grain yields were 2,600; 3,070; 3,090; 2,960; and 2,680 kg/ha. The grain yield data indicate the problems encountered with dryland

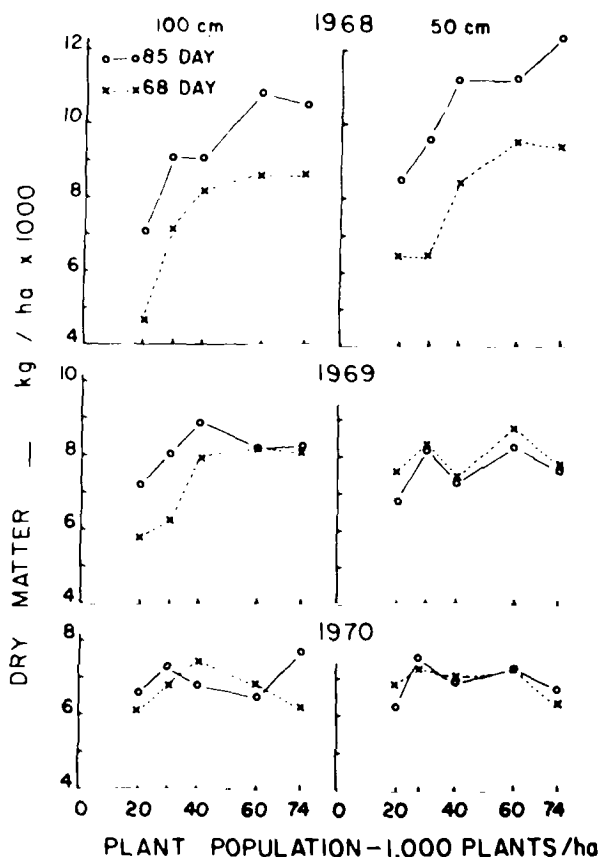


Fig. 2. Dry matter production of corn as affected by population, row, spacing and relative maturity.

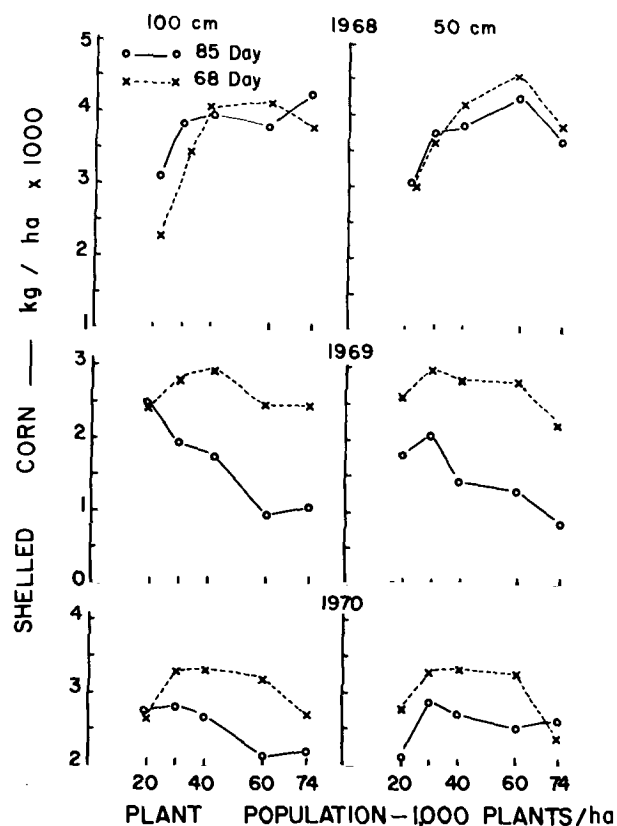


Fig. 3. Grain production of corn as affected by population, row spacing, and relative maturity.

corn planted at high rates. Average grain yield for the 50 and 100-cm row spacings were 2,890 and 2,870 kg/ha, respectively, indicating no advantage of narrow corn rows.

Several characteristics of the grain produced are shown in Fig. 4. The early-maturing corn had fewer barren stalks and higher ear weight than the later-maturing corn at all populations. For both corn hybrids, number of ears per stalk and ear weight decreased as population increased. Percent water content in ears was higher for the 85 RM variety and increased somewhat with population. However, all grain each year was reasonably mature at harvest. Seasonal variation in water content of ears was 10 to 20%. These ear characteristics were similar for both row spacings (data not shown).

In the northern Great Plains, corn production is hampered by a short growing season, and rising temperatures and declining precipitation as the season progresses. Thus, crop management is important. These results indicate that optimum plant population for grain and forage was in the range of 30,000 to 40,000 plants/ha (12,000 to 16,000 plants/acre), regardless of the maturity class of the variety. Spacing plants wider apart within a given row spacing tended to produce bigger ears per stalk than plants spaced closer together, but the magnitude of plant competition determined the number of ears produced per unit of area. A later-maturing hybrid produced more dry matter, but an early-maturing variety produced more grain.

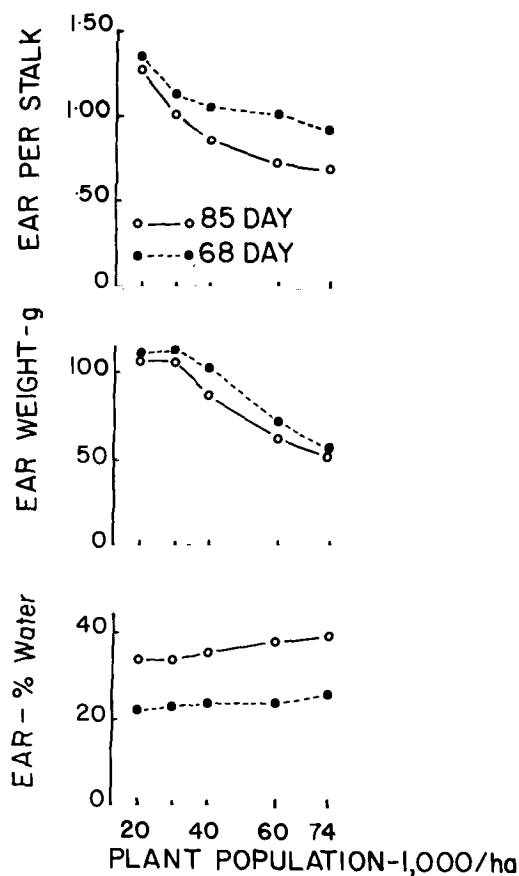


Fig. 4. Corn ear characteristics as affected by population and maturity class (average of both row spacings).

The results of this work indicate that narrow row spacing is of little benefit for dryland corn production. Generally, a lack of available water during grain formation and filling is the factor limiting corn production in the Great Plains. Planting systems that conserve water during early summer for use later during grain formation have generally proved most successful. Conservation of water can be achieved in part by controlling plant population (1, 5, 16), but it appears that row spacing is of little consequence. Only in 1968, a year of sufficient water, was there any evidence that this factor was important.

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